Onderstepoort J. vet. Res., 57, 189–195 (1990)

A SURVEY OF ANNOYANCE OF LIVESTOCK BY *SIMULIUM CHUTTERI* LEWIS ALONG THE ORANGE RIVER, SOUTH AFRICA (DIPTERA: SIMULIIDAE)

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ABSTRACT

JORDAAN, LEONORA C. & VAN ARK, H., 1990. A survey of annoyance of livestock by *Simulium chutteri* Lewis along the Orange River, South Africa (Diptera: Simuliidae). *Onderstepoort Journal of Veterinary Research*, 57, 189–195 (1990).

A survey by means of questionnaires was conducted along the Orange River to determine the extent of blackfly annoyance to livestock during 1984–1988. Severe annoyance reached peaks during September–November and increased over the years. Annoyance levels decreased with distance from the river with occasional severe annoyance as far away as 76 km.

Annoyance levels increased with distance downstream from the P. K. le Roux dam to Augrabies (750 km). Greater water releases for increased irrigation and electricity generation may be an important reason for the higher annoyance levels. Present day high and increasing irrigation water requirements and the great length of the river probably render control by water level fluctuations impractical.

Loss of condition of especially small livestock is the main consequence of annoyance by female blackflies. Decreased percentage lambing and occasional deaths were also reported.

INTRODUCTION

Following the completion of the Hendrik Verwoerd and P. K. le Roux dams in the upper reaches of the Orange River in the 1970's, the *Simulium chutteri* problem, previously confined to the Vaal River (Howell & Holmes, 1969), spread to the Orange River. The diversion of water from the Orange River system to the Fish River system via the 80 km long Orange-Fish tunnel extended the blackfly problem even further to the Great Fish River (O'Keeffe, 1985).

The extent of the problem along the Orange River was first evaluated in 1979 by G. J. Begemann of the Veterinary Research Institute, Onderstepoort by means of a single survey of questionnaires to farmers (V.R.I., unpublished data, 1979). Dr M. Car succeeded Mr Begemann and conducted a very limited survey of follow-up questionnaires in 1982 (V.R.I., unpublished data, 1982). In 1983, one of the authors (L.C.J) succeeded Dr Car and undertook a more extensive survey of the blackfly problem, the results of which will be reported here.

The purpose of the present survey was primarily to determine the level of annoyance at various times of the year, the distance from the river over which blackflies caused annoyance and the sections of the river where the problem is most serious.

It must be emphasized that information from these questionnaires should be regarded as subjective and that not too much value should be attached to specific quantities or frequencies as such. The aim is therefore to show the more pronounced general trends observed.

MATERIALS AND METHODS

Initially, questionnaires were sent to 750 farmers along the Orange River from the P. K. le Roux dam to Oranjemund, a distance of approximately 1 369 km. An area of up to approximately 80 km on both sides of the river was covered. Only 215 farmers returned the questionnaires fairly regularly and these were used to determine the extent of female blackfly annoyance for 1984 to 1987. During 1988, 74 questionnaires only were sent out for only October and November. Questionnaires were sent out on a monthly basis, but somewhat irregularly, as indicated in Fig. 1.

Received 10 May 1990—Editor

FIG. 1 Months for which questionnaires were sent to farmers along the Orange River

The main question asked in the questionnaires was: To what extent did blackflies annoy livestock during the previous month? Four annoyance levels were used, viz.: 0 = none, 1 = light, 2 = moderate and 3 = severe. For the purpose of analyses 2 methods of demarcation were used, viz.:

a. For distances away from the river, 4 parallel zones were chosen with approximately equal numbers of respondents, viz.: $< = 5$ km, 6–20 km, 21–40 km and > 40 km.
b. For sections of the river downstream of the P. K. le Roux dam, natural demarcation points were chosen, viz.: From the P. K. le Roux dam to Douglas (confluence of the Orange and Vaal rivers), from Douglas to the Boegoeberg dam, from the Boegoeberg dam to the Augrabies waterfall and from the Augrabies waterfall to Oranjemund.

Questionnaires from farms situated $\leqslant 20$ km from the river were used for the comparisons between sections of the river. Details for the 4 sections are given in Table 1.

Trends in annoyance levels were determined by means of annoyance indices for each parallel zone and/or each river section. An annoyance index was calculated for each month by summing the product of the frequencies for the annoyance levels and the numerical indices and dividing by the total frequency of response, e.g.:

Annoyance index = $(23 \times 0 + 34 \times 1 + 54 \times 2 + 43 \times 3)/154 = 1{,}76$.

For some trends averaged annoyance indices were used, details whereof will be given when the concerned results are discussed.

From July 1987 onwards the duration of annoy-

TABLE 1 Details for the 4 sections of the Orange River

Section	1	2	3	4
Boundaries	P. K. le Roux to Douglas	Douglas to Boegoeberg	Boegoeberg to Augrabies	Augrabies to Oranjemund
Number of respondents	31	37	17	20
Mean distance from river (km)	9,8	6,5	7,2	9,6
Distance from P. K. le Roux dam (km)	0–191	191–476	476–749	749–1369
Longitudinal boundaries	24°48′E to 23°39′E	23°39′E to 22°15′E	22°15′E to 20°19′E	20°19′E to 16°25′E

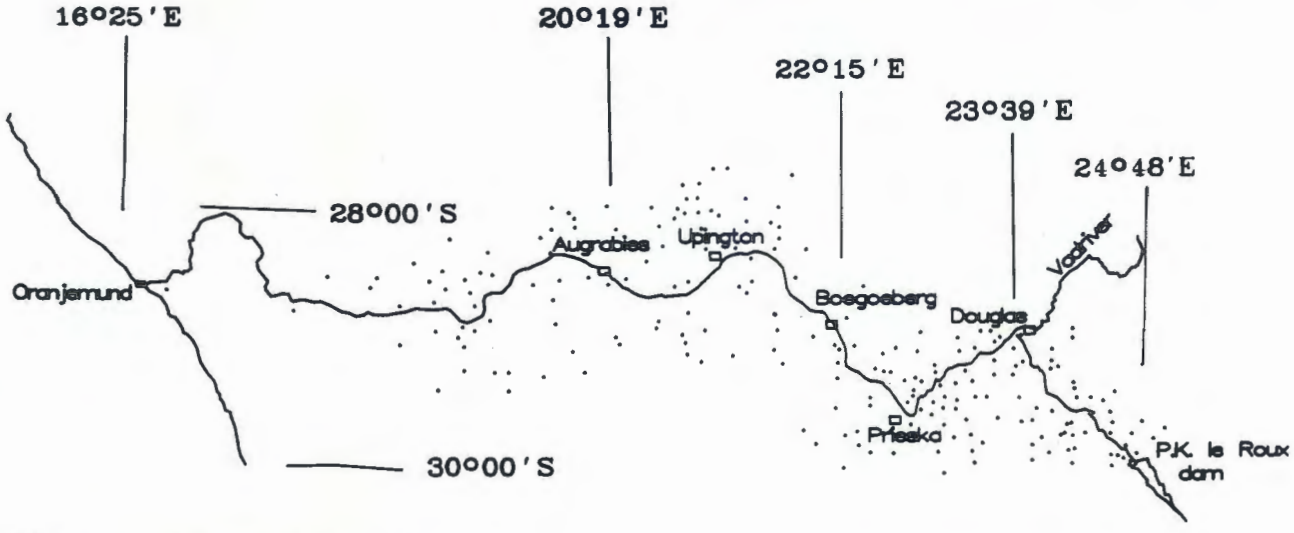

FIG. 2 Location of the farms of the respondents

ance was also recorded in weeks during each specific month. Some bias may exist here, because some respondents may have interpreted this question as referring to the specific week of the month in which annoyance occurred and not the number of weeks with annoyance.

Originally, losses due to annoyance were also reported, but because nearly all farmers regarded losses as deaths only (which occurred very infrequently) and not losses in condition, the questionnaires were altered from July 1987 onwards to obtain information on loss of condition, deaths and reduced percentage lambing.

The farms of all respondents were located on 1:250 000 maps and the approximate shortest distance (in km) from the river measured using these maps. The rather irregular distribution of the farms used and the longitudinal demarcation lines for the 4 sections of the river are shown in Fig. 2 (see also Table 1).

RESULTS AND DISCUSSION

Annoyance by females in parallel zones along the Orange River

Seasonal annoyance

To determine if annoyance levels decreased with distance from the river, the monthly annoyance indices calculated for each consecutive zone along the river were used to draw smoothed curves. These curves are presented in Fig. 3.

From Fig. 3 it is clear that seasonal annoyance decreased for nearly all months with an increase in distance from the river. This trend is expected because the success rate of a female blackfly obtaining a bloodmeal from an animal and returning to the river for oviposition decreases with an increase in the distance it has to fly.

The seasonal annoyance curves seemed to be remarkably synchronized for the 4 parallel zones over all seasons. To determine, therefore, if any significant differences in annoyance ratios over months existed between these 4 zones, chi-squared tests were carried out on the annoyance indices (multiplied separately by 100) for July–April for each season. The only significant difference ($P < 0,05$) evident was between the > 40 km distance and the other distances for the 1984/85 season.

Annoyance levels peaked during September–November, with relatively low annoyance levels during the winter months. The increase in annoyance was very rapid from August onwards and decreased at a slower rate from November onwards. There was little evidence of a marked 2nd peak during February–March as has been suggested by some farmers. A 2nd peak does occur along the Great Fish river (State Veterinarian, Grahamstown, unpublished data, 1988). Complete absence of blackflies during December and later has been noted by some farmers, but this is not generally evident in Fig. 3. Owing to the rapid decrease in annoyance, this condition may only be present on some farms, thus giving rise to this assertion (see also "unevenness of annoyance").

Increase in annoyance

To determine if peak annoyance during the summer months increased over successive seasons, the annoyance indices for the peak month, the month before and the month after, were averaged for each year. Questionnaires for 1988 were available for only October and November, the latter month having the highest annoyance levels. Assuming that November represented the month with peak annoyance, the mean index for October was regarded as the probable mean index for December. This was

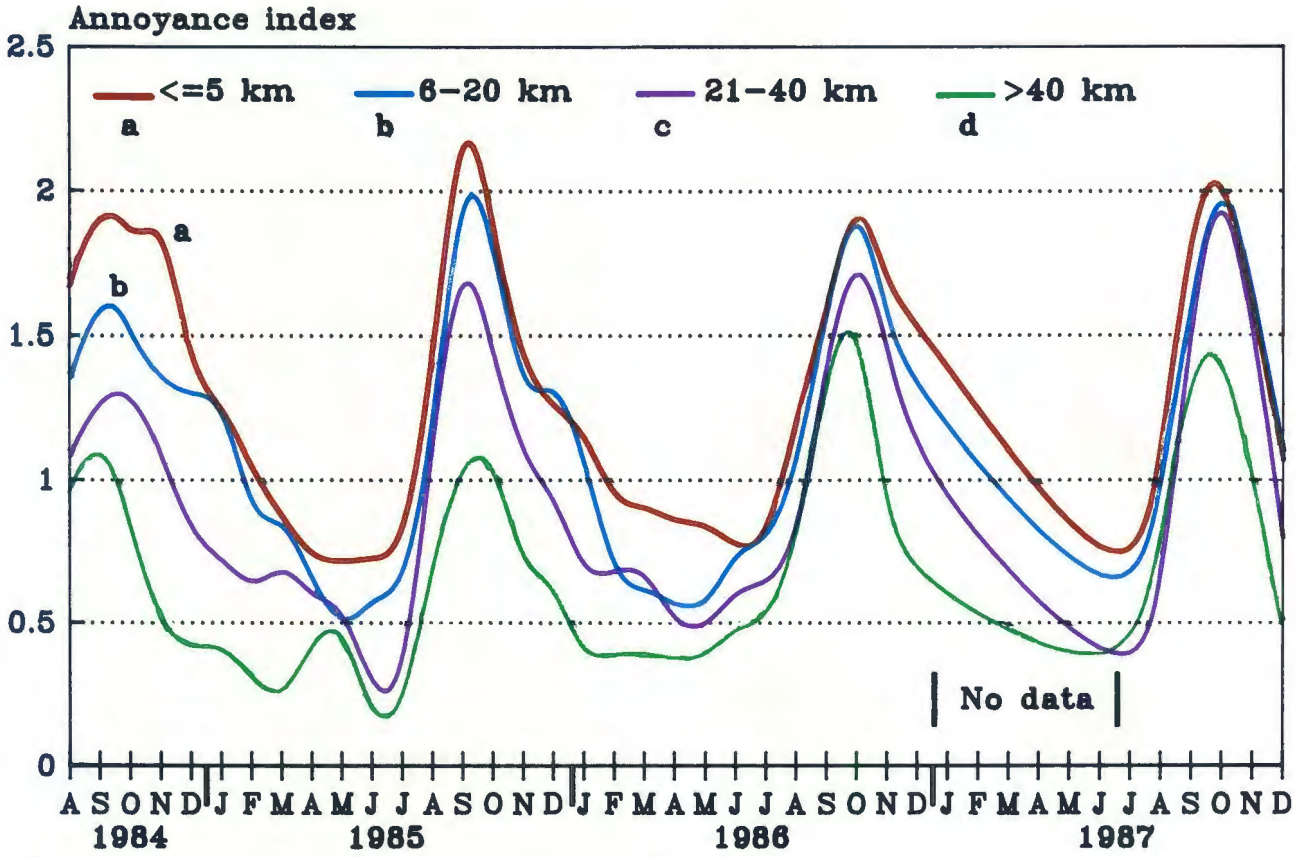

FIG. 3 Annoyance by female blackflies in 4 parallel zones along the Orange River

done in order to obtain reasonably comparable data for 1988. The smoothed curves for the averaged indices for each of the 4 zones are plotted in Fig. 4.

The curves in Fig. 4 indicate that, although variations are evident, annoyance during peak months increased with successive seasons. If this trend is maintained and if maximum blackfly population densities have not been reached, the blackfly problem could intensify.

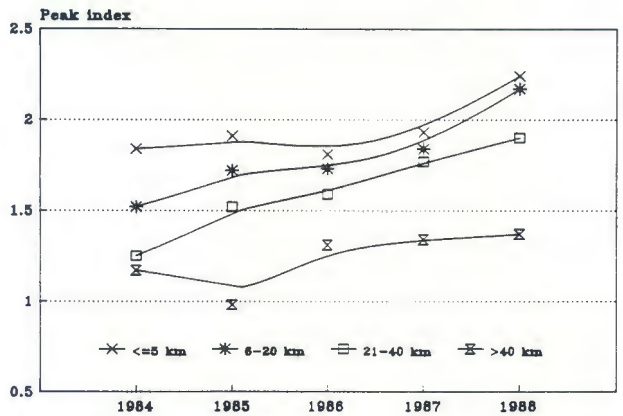

FIG. 4 Increase in peak annoyance in 4 parallel zones along the Orange River

Increased water releases from the P. K. le Roux dam to accommodate increasing irrigation needs result in higher water levels in the river. This could in turn provide more living space and/or more favourable larval and pupal habitats which in turn would result in increases in blackfly annoyance. The annoyance indices, averaged for the 4 zones and for the 3 peak months of each year, were therefore compared with the mean daily cumecs of water released at the dam during these peak months. Water releases exceeding 400 cumecs during 1987 were omitted because these were considered abnormally high because of excessive rainfall. A highly significant positive linear correlation [$r_{(3)} = 0{,}96$, $P < 0{,}01$] was evident. Increasing water releases accounted for as much as 92,2 % of the variation in the mean peak annoyance index. The trend for this correlation together with the 95 % confidence limits are given in Fig. 5.

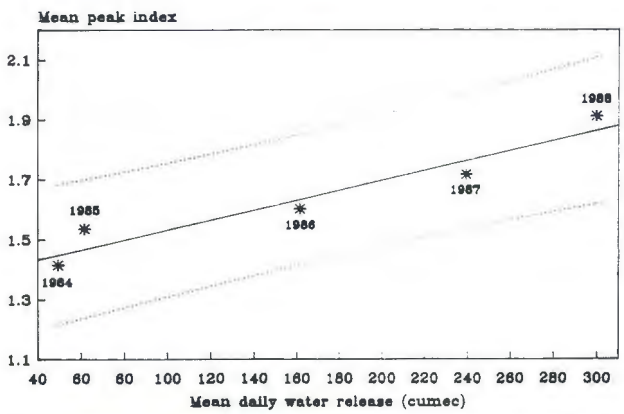

FIG. 5 Relation between peak annoyance and water release from the P. K. le Roux dam

Unevenness of annoyance

From Fig. 3 and 4 it is evident that the annoyance indices during peak months did not reach 2,5, an indication that not all farms, even those near the

river, simultaneously experienced severe annoyance levels (index = 3) during the summer months. To obtain an indication of these frequencies, the relative annoyance on all farms, expressed as percentages of the frequencies for the 4 annoyance levels for the 3 peak months over all 5 years, was calculated for each zone along the river. The results are presented in Fig. 6.

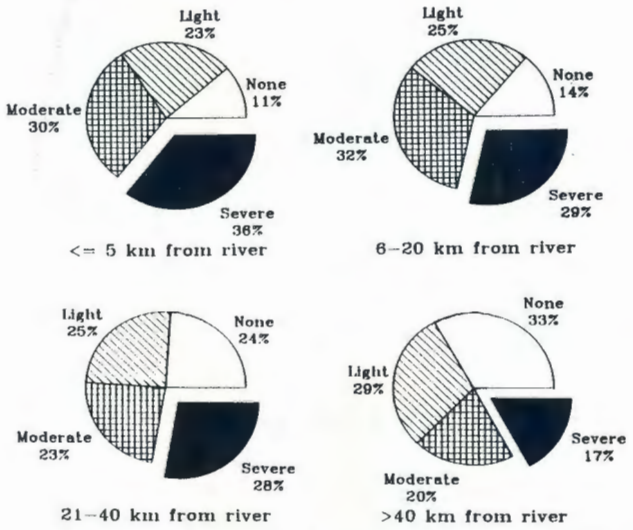

FIG. 6 Relative annoyance for peak months along the Orange River

Fig. 6 shows that a $\frac{1}{3}$ of the respondents near the river reported none or only light annoyance levels. The trend increased with distance from the river. Differences in environmental factors, such as irregularly distributed larval breeding sites, direction and speed of prevailing winds etc. and geographical factors, such as topography may be responsible for this.

From Fig. 6 it is also evident that the frequency of severe annoyance decreased with distance from the river. To obtain an indication of the severity of annoyance far from the river, annoyance levels on farms situated at distances of more than 70 km from the river are given in Table 2.

TABLE 2 Annoyance frequencies for farms further then 70 km from the Orange River

Farm No.	Section	Distance (km)	Questionnaires returned	Annoyance	
				Moderate	Severe
95	4	72	31	2	0
103	3	72	27	8	11
181	3	72	29	0	0
182	3	72	31	2	0
471	3	72	33	0	0
96	4	74	26	0	0
81	3	74	29	4	7
97	4	74	29	1	0
177	3	76	29	8	5

The data in Table 2 indicate that severe annoyance by blackflies did occur as far away as 76 km from the river. Such annoyances, however, were far less frequent than those nearer to the river. Unfortunately, all the concerned farms are situated in sections 3 and 4 and no comparison between sections is possible.

Annoyance by females in sections of the Orange River

Except for general decreases with distance from the river, the relative seasonal increases and decreases in annoyance were very similar for the 4 zones along the river within each season. Consequently, only those farms situated ≤ 20 km from the river were used to determine if the annoyance levels along the river changed from the P. K. le Roux dam to Oranjemund (see MATERIALS AND METHODS). Smoothed curves were drawn for the monthly annoyance indices. These curves showed considerable variations between sections and pairwise comparisons of the 4 sections were necessary to obtain clear annoyance trends. The pairs of curves and the periods at which the P. K. le Roux dam was closed for 60 h during 6 consecutive weekends are presented in Fig. 7.

Effect of closures of the P. K. le Roux dam

Howell, Begemann, Muir & Louw (1981) and also Car (1983) suggested that regular closure of the dam and water-level regulation could be an effective control measure as drying out of pupae and disturbance of larvae would thus probably reduce annoyance by blackflies to acceptable levels. Fig. 7A and 7B clearly indicate that the closures during 1984 to 1987 did not result in drastic reduction of annoyance levels. Any reduction was more noticeable during the winter months than in the peak summer months. The possible effects of other environmental factors in the river, such as lower water temperatures and regular water fluctuations resulting from silt control and generation of hydroelectric power, inflow of water from the Vaal river etc. on these reduced annoyance levels cannot be ruled out. Owing to the length of the Orange River, the 60-hour periods of dam closures are probably too short to cause prolonged drastic drops in water level further from the dam than approximately Prieska.

Annoyance levels and occurrence during seasons

Fig. 7 clearly shows that annoyance levels and their occurrence differed considerably between the 4 different sections.

Although variations did occur, Section 3 tended to have the highest annoyance levels (Fig. 7B & D), while the smallest annoyance levels were evident for Section 4 (Fig. 7C, E & F). Annoyance levels generally increased from the P. K. le Roux dam towards Augrabies and decreased from there to Oranjemund. This trend is especially noticeable for the 1986/87 season.

Another accompanying trend is that the further away from the P. K. le Roux dam the earlier the seasonal annoyance-level build-up towards the summer months occurred for the consecutive sections up to Augrabies (Fig. 7A & B). However, the start of the summer build-up for Sections 3 and 4 occurred approximately at the same time (Fig. 7F). It is possible that temperature may be one of the more important influential factors for these trends. Higher water temperatures towards the west may be responsible for more favourable habitat conditions for the larvae during the late winter and early summer months, while the extreme aridity, lack of cover and lower animal densities may limit activities of adult blackflies in Section 4 (furthest west). Unfortunately, no reliable water temperature readings are available, but long-term mean air temperatures increased from east to west. The effect of water regulation and fluctuations on the observed annoyance levels in Section 1 and 2, however, can not be discarded.

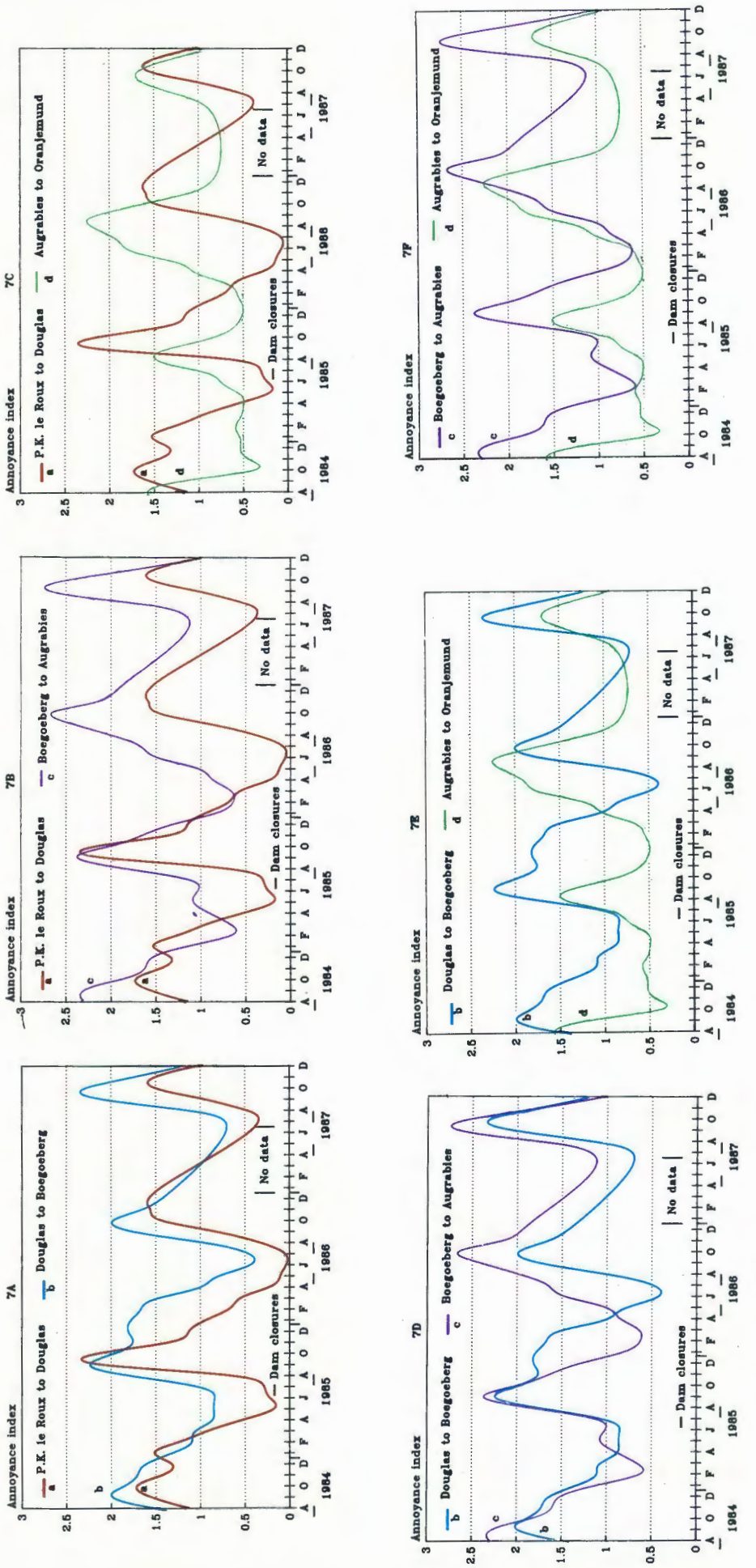

FIG. 7 Annoyance by female blackflies in 4 sections of the Orange River

Duration of annoyance levels

To obtain some indication of the duration of annoyance, the mean number of weeks per month during which annoyance occurred, irrespective of severity, from July–December 1987 were calculated for each of the 4 sections of the Orange River. The smoothed curves drawn through these values are presented in Fig. 8.

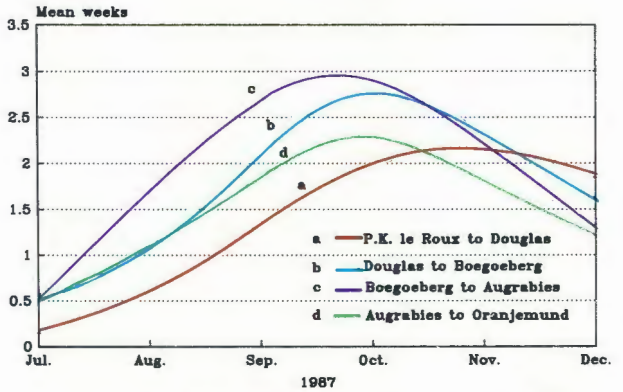

FIG. 8 Duration of annoyance in sections of the Orange River

Trends similar to those obtained for the annoyance levels (Fig. 7) are evident in Fig. 8. Section 3 showed the fastest increase in duration during the spring and summer months. The duration of annoyance increased latest in the season for Section 1, possibly caused by water regulation and fluctuations and/or lower water temperatures. The duration of annoyance for Sections 2 and 4 was approximately similar during July–August, after which the increase in duration was less for Section 4, possibly because of adverse arid conditions. Data was available only for 1987, but it may be reasonable to assume that the observed trends were true for most seasons.

Losses from annoyance by females

Losses in condition and deaths caused by annoyance by females during July–December of 1987 and October and November of 1988, for all zones in the 4 sections of the Orange River, are presented in Fig. 9. The frequencies of reported losses are expressed as percentages of the total number of questionnaires received.

According to Fig. 9 the occurrence of loss of condition to small livestock increased with distance from the P. K. le Roux dam, except for a decrease in Section 4. The mean distances from the river for the farms concerned in the 4 sections were 18,6 km, 20,0 km, 35,3 km and 27,4 km. If more farms near the river for Section 3 and to a lesser extent Section 4 had been surveyed, the percentage occurrence of loss of condition would probably have been higher for these 2 sections. In general, the increase in loss of condition corresponded with the increase in annoyance by females in the sections (Fig. 7).

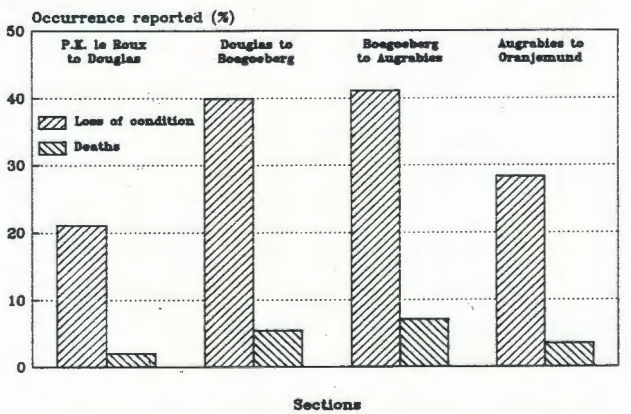

FIG. 9 Losses due to annoyance in sections of the Orange River

Deaths from female blackflies were relatively very low, but their increase follows the same trend as that for loss of condition.

Losses should increase with increased annoyance and, to obtain an indication of relative increases in losses with duration, the frequencies of losses reported in 1987 and 1988 from serious annoyance only, were expressed as percentages for each of the 4 duration classes (1 to 4 weeks). These percentages are presented in Fig. 10.

Taking the probable misinterpretation by the respondents of the duration of annoyance into consideration, it is clear from Fig. 10 that loss of condition was markedly higher when severe annoyance occurred for 2 weeks and longer than for 1 week only. Because duration of annoyance within each week may vary considerably with distance from the river and prevailing wind effects, and because the response frequencies in each category differed, it is probably correct to conclude that loss of condition from annoyance for 2, 3 and 4 weeks follows the same pattern.

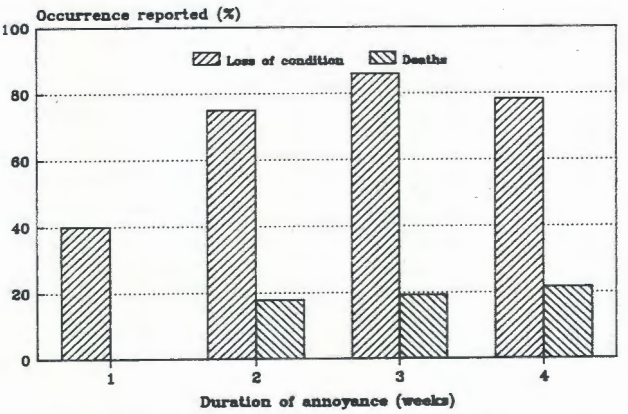

FIG. 10 Losses due to severe annoyance during 1987 and 1988

No deaths were reported when serious annoyance lasted only a week, and approximately 20 % of the respondents reported deaths when serious annoyance lasted from 2–4 weeks.

Reduction in percentage lambing could not be accurately assessed from the questionnaires because of different periods of lambing and irregular returns of questionnaires. For periods of serious annoyance, however, approximately 50 % of the respondents reported reduced percentage lambing.

Effect of wind on severity of annoyance by females

Because the adult blackflies are very small, wind could effect annoyance levels considerably. Volunteered information by the respondents indicated that blackfly annoyance was more severe when the prevailing wind blew from the river. It is assumed that the wind speeds involved were not excessive, because high wind speed would probably be a limiting factor for blackfly dispersal.

CONCLUSIONS

Annoyance by blackflies is very severe along the Orange River during the summer months of September–November and will probably increase in future if demands for more irrigation water and electricity generation increase. Finding effective control measures is therefore of paramount importance.

Not all farms experience simultaneously the same level of severity of annoyance, probably because of the effects of a number of environmental factors. Such unevenness necessitates the use of a relatively large number of respondents for an ongoing assessment of the status of the annoyance problem and for determining the effectiveness of control measures. Using only a small number of sampling points or respondents could result in serious bias.

Dam closures at 6 consecutive weekends during the winter months did not drastically reduce blackfly annoyance levels. It seems that many more, regular dam closures for much longer periods are needed to drastically reduce pupae (and larvae) in the Orange River from the dam to Oranjemund. Intensive research on the effects of different water regulation regimens on larval populations and resulting blackfly annoyance would be necessary to determine the most effective water regulation regimen. Such research would seriously inconvenience current irrigation practices and electricity generation and would probably be unacceptable to the parties concerned. Water regulation, therefore, has limited value in blackfly control in the Orange River.

Considerable differences in annoyance levels were present in the 4 arbitrary large sections of the river, probably due to the effects of a complex of environmental factors. Differences in blackfly population densities and consequently annoyance levels may be even more pronounced in smaller and ecologically more accurately defined sections of the river. Because of the great length of the river use of a completely uniform control measure will probably not be feasible. Intensive research on blackfly population dynamics along the whole river is therefore indicated to ensure future implementation of optimum control measures.

ACKNOWLEDGEMENTS

Sincere appreciation is expressed to all farmers who for so many months responded faithfully to the monthly questionnaires. Dr E. M. Nevill is thanked for critisizing the first draft of the manuscript.

REFERENCES

CAR, M., 1983. The influence of water-level fluctuation on the drift of *Simulium chutteri* Lewis 1965 (Diptera: Nematocera) in the Orange River, South Africa. *Onderstepoort Journal of Veterinary Research*, 50, 173–177.

HOWELL, C. J. & HOLMES, G. W., 1969. The control of Simuliidae in the Vaalharts irrigation complex. *Journal of the South African Veterinary Medical Association* 40, 59–67.

HOWELL, C. J., BEGEMANN, G. J., MUIR, R. W. & LOUW, P., 1981. The control of Simuliidae (Diptera: Nematocera) in South African rivers by a modification of the water flow volume. *Onderstepoort Journal of Veterinary Research* 48, 47–49.

O'KEEFFE, J. H., 1985. The blackfly problem in the Great Fish River. *Naturalist* 29, 3–8.